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Subduction-induced mantle flow and dynamic uplift around the Patagonian slab window: insights from laboratory models

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We present dynamically self-consistent mantle-scale laboratory models that have been conducted to improve our understanding of the influence of slab window opening on subduction dynamics, mantle flow and associated dynamic topography over geological time scales. The adopted setup consists of a two-layer linearly viscous system simulating the subduction of a fixed plate of silicone (lithosphere) under negative buoyancy in a viscous layer of glucose syrup (mantle). Our experimental setting is also characterized by a constant-width rectangular window located at the center of a laterally confined slab, modeling the case of the interaction of a trench-parallel spreading ridge with a wide subduction zone. We found that the opening of a slab window does not produce consistent changes of the geometry and the kinematics of the slab. On the contrary, slab-induced mantle circulation, quantified both in the vertical and horizontal sections using the feature tracking image analysis technique, is strongly modified. In particular, rollback subduction and the opening of the slab window generate a complex mantle circulation pattern characterized by the presence of poloidal and toroidal components, with the importance of each evolving according to kinematic stages. Mantle coming from the oceanic domain floods through the slab window, indenting the supra-slab mantle zone and producing its deformation without any mixing between mantle portions. The opening of the slab window and the upwelling of sub-slab mantle produce a regional-scale non-isostatic topographic uplift of the overriding plate that would correspond to values ranging between ca. 1 and 5 km in nature. Assuming that our modeling results can be representative of the natural behavior of subduction zones, we compared them to the tectonics and volcanism of the Patagonian subduction zone. We found that the anomalous backarc volcanism that has been developing since the middle Miocene could result from the lateral flow of sub-slab mantle and that part of the Patagonian uplift could be dynamically supported.